DOCUMENT RESUME

ED 121 663 SO 009 035

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TITLE The Mathematics Filter and the Education of Women and Minorities.
PUB DATE Feb 76
NOTE 20p.; Paper presented at Annual Meeting of the American Association for the Advancement of Science (Boston, Massachusetts, February 18-24, 1976)

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage
DESCRIPTORS Achievement Rating; College Entrance Examinations; Cultural Factors; Educational Opportunities; Equal Education; Ethnic Status; Higher Education; *Mathematical Experience; *Mathematics Education; *Minority Groups; Nondiscriminatory Education; Secondary Education; *Secondary School Mathematics; Sex Differences; *Womens Education

ABSTRACT

Level of high school mathematics achievement acts as a critical filter to eligibility for undergraduate admission of minorities, particularly blacks, and effectively limits their opportunities in the world of work. Level of high school mathematics achievement acts, also, as a critical filter in keeping women from free choice of an undergraduate major and, thus, effectively limits their opportunities in the world of work as well. A questionnaire survey, based on information presented in a 1973 study of San Francisco high school students and on the 1965 Coleman Report on 12-grade median achievement in mathematics nationwide, was presented to social science students at the University of California in 1973 to determine the specifics of their mathematical background. Dissemination of factual information on mathematics background to students, parents, teachers, counselors, and administrators should help overcome sex and ethnic differences by calling attention to the problem and implications of lower mathematics achievement among women and minority groups. The data provide an opportunity for a value-free consideration of what happens differently at home, among peers, and in the classroom to produce observable behavior differences. The data provide, also, an opportunity for all of us to contribute solutions to the problem, regardless of sex, ethnicity, or role and status in the educational, economic, or political system. (Author/DDB)

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The Mathematics Filter and the Education of Women and Minorities

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Abstract

Level of high school mathematics achievement acts as a critical filter to eligibility for undergraduate admission for Blacks. This effectively limits their opportunities in the world of work. Level of high school mathematics achievement acts as a critical filter in keeping women from free choice of undergraduate major. This effectively limits their opportunities in the world of work. Dissemination of these facts to students, parents, teachers, counselors, and administrators will help overcome sex and ethnic differences, by calling attention to the problem, in a way which frees them to consider what happens differently at home, among peers, and in the classroom to produce the differences observed in the data. Rather than serving as an excuse to find fault and place blame on others, the data provide an opportunity for all of us to contribute solutions to the problem, regardless of sex, ethnicity, or role and status in the educational, economic, or political system.

The Mathematics Filter and the Education of Women and Minorities

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The Problem

College and universities vary considerably in the amount of high school mathematics preparation they require or recommend for entering freshmen.[1] This institutional variation in requirements and recommendations of high school mathematics has important implications for freedom of access to undergraduate admission, and for freedom of choice of undergraduate major in college. Students whose arithmetic skills are too far below grade level in high school are effectively barred from access to the first year of high school algebra, which is the minimal mathematics preparation required by most colleges and universities. Students who have had three and a half to four full years of high school mathematics are immediately eligible for the standards freshman calculus sequence at any college or university in the country. Unitl very recently those students who had not pursued second year algebra and trigonometry in high school had no way of catching up before entering as freshmen, to qualify for the standard calculus sequence, which is required for undergraduate majors in every major field except education, criminology, the social sciences, and the humanities.[2] These fields have almost no current job related potential for persons with bachelor's degrees.

There is a rapidly growing literature on the importance of mathematics as a critical filter in shutting off opportunities for women and non-Asian minority students (Dornbusch, 1974; Ernest, 1975; Fox, 1974; Helson, 1972 and Berglund, 1973; Jacklin and Maccoby, 1972, 1974; Levine, 1975; Osen, 1971, 1973, 1974; Sells, 1974; Tobias, 1975).

Because the filtering effect works to bar minorities from access to college and university admission sooner than it tends to close off options for choice of undergraduate major for women, minorities will be covered first.

Lack of mathematics achievement in high school as barrier to minorities

A recent study of San Francisco high school students shows a pattern of larger ethnic differences than sex differences in attitudes, behavior, and performance in mathematics. (Fernandez, Espinosa, and Dornbusch, 1975). Only among the Blacks in the eighth grade was there a large and statistically significant sex difference in performance, in the opposite direction from what one would predict by sex. While 69 percent of the Black males in the eighth grade scored below 5.2 grade level, only 38 percent of the Black females did so.

At the tenth grade level, this sex difference had all but disappeared, with more than half the Blacks performing at less than 6.6 grade level, compared with 17 percent of the Chicanos, eight percent of the whites, and one percent of the Asians. The percentage of Blacks with ten or more unexcused absences during the previous semester was 39, compared with 28 percent of the Chicanos, 17 percent of the whites, and eight percent of the Asians. The percentage of Blacks reporting spending two or more hours a week on mathematics homework was 28, compared with 31 percent of the Chicanos, 44 percent of the whites, and 60 percent of the Asians. The percentage of Blacks who received A's and B's in mathematics was 18, compared with 33 percent of the Chicanos, 38 percent of the whites, and 53 percent of the Asians.

The study has important implications for ethnic differences in undergraduate admission. More than half of the Asian students earned grades in mathematics high enough for admission to most colleges and universities. Less than one fifth of the Black students earned those kinds of grades. Further research needs to be conducted on what happens differently to Asians and to Blacks, in the home, on the schoolyard, on the streets, and in the classroom, to produce such large differences in attitude, behavior, and performance in mathematics.

The evidence from this 1973 sample of high school students in San Francisco is supported by data on twelfth grade median achievement test scores in mathematics, nationwide, in 1965 (Coleman, et al., 1966). The median achievement score of Black twelfth grade students was 41.8, compared with 51.8 for white students, a difference of one standard deviation.

These two studies demonstrate the difficulties of opening opportunities for minorities at the post-secondary education level through affirmative action, without first addressing the problem of equalizing skills at the primary and secondary education levels.

Lack of mathematics achievement as filter for women

It has been shown that girls start out equally with boys in the development of arithmetic skills (Maccoby and Jacklin, 1973). Most studies show no sex differences in mathematics ability up to adolescence, but when differences are found, they tend to favor boys. The literature shows that after about thirteen, boys start to move ahead in mathematics ability, and the gap widens with each additional year of schooling (Maccoby and Jacklin, 1973, 1974; Poffenberger and Norton, 1963 and Very 1967). The whole question of the impact of puberty on girls, at the same

time as their first exposure to male teachers, in junior high school mathematics courses suggests the need for further research.

Although the San Francisco study gives cross-sectional rather than longitudinal data, one could infer possible effects of puberty on Black females from the shift from 38 percent in the bottom fifth of all students at the eighth grade level to 59 percent in the bottom fifth of all students at the tenth grade level.

There is need for further research on the distinctions between arithmetic, involving memorizing skills of addition, subtraction, multiplication, division, and mathematics skills, involving abstract thinking and analytical.

In addition to possible biological and psychological effects of puberty on mathematics achievement, there was, until the final Title IX Regulation Implementing Education Amendments of 1972 prohibiting sex discrimination in education a universal tracking of seventh grade girls into cooking and sewing, and of seventh grade boys into mechanical drawing, wood shop, and metal shop. There is work being done at the University of California, Los Angeles, which shows the importance of mechanical drawing in developing spatial relationship abilities (Alspektor, 1975) which are crucial for survival and flourishing in high school mathematics. There is solid evidence on sex differences in mathematics achievement.

The author conducted a pilot study to test the contention that inadequate mathematics preparation of women in high school places a serious constraint on their choice of undergraduate major in college. On the basis of the minimal requirement for admission, it was hypothesized that women accepted for admission at Berkeley would be less likely to have taken

advanced mathematics in high school than men, and therefore would be barred from various undergraduate majors, particularly in the physical sciences.

A systematic random sample of names was drawn from the computer printout of people accepted for admission as freshmen at Berkely for the fall of 1972. The folders were pulled from the files, and coded by sex and number of years of high school mathematics preparation. Some students took only the minimum two year entrance requirement, some took three years, and some took the three and a half years required for admission to the freshman calculus course.

The distribution is presented in Table 1. The difference of forty-nine percentage points between men and women among those who took three and a half years of high school mathematics is striking.

Insert Table 1 about here

The fact of the high school mathematics filter has frequently been interpreted as proof of discrimination against high school girls, even as teachers and counselors have interpreted it as proof of self-selection on the part of the students. When the fact is presented to groups of students, parents, teachers or in testimony on the need to pay attention to it, someone invariably asks why the fact of sex and ethnic differences in mathematics is a problem, suggesting that maybe girls and and Blacks don't take trigonometry and analytic geometry in high school because they don't want to, and isn't freedom of choice a good thing? The crucial question is what is it that happens differently for girls and for boys, for Blacks, Chicanos, whites and Asians at home, in elementary school, among peers,

and in the classroom, that shapes and determines their wanting to take trigonometry and analytic geometry and that shapes their ability to perform and achieve?

Evidence is strong that the ostensible freedom of choice not to take as much mathematics as one can handle operates to close off opportunities for minorities and women.

To test the hypothesis that climates of expectation and social support influence decisions to take or not to take advanced mathematics in high school, a questionnaire was distributed to members of an upper division social science class. It contained questions about performance in elementary school arithmetic and in high school mathematics; expectations and encouragement by teachers, parents and peers; and whether the respondent had taken mathematics beyond the minimal two-year entrance requirement. The distribution of responses is presented in Table 2.

Insert Table 2 about here

There is a strong relationship, Q = .94, between reported social support and taking advanced mathematics in high school. There is a similar strong relationship, Q = 1.00, between having reported social support and level of performance in advanced courses in high school mathematics. Table 3 shows that all of those reporting some social support for taking advanced high school mathematics courses received As and Bs, and more than half of those reporting no social support received Cs and Ds in those courses.

Insert Table 3 about here

While it is not possible to generalize beyond this small sample of social science undergraduates, the magnitude of the relationship between reporting social support, taking advanced high school mathematics courses and performing well in them suggests the need for further research and action to increase levels of social support. Table 4 shows the crucial importance of adequate high school mathematics in filtering people out of majors in the physical sciences, life sciences and mathematics. Note that the percentage of Asian women in these fields exceeds the percentage of white or Black men, which is consistent with the findings of the San Francisco study.

Insert Table 4 about here

This paper has shown that more than half of the Blacks in a sample of high school students are barred from access to major colleges and universities by poor performance in arithmatic and mathematics skills. It has shown that 92 percent of entering freshman women at one major university are barred from access to undergraduate majors which require the freshman calculus sequence in the first year.

In using the data to elicit theories about what is happening in the home, the schoolyard and the classroom to produce the sex and ethnic differences in mathematics achievement, the following results have occurred: some people have been quick to infer lower ability levels on the part of Blacks and of females. Some people have been quick to infer lower expectations on the part of teachers for Blacks and for females in performance. Some people have been quick to infer freedom of choice and lack of interest in the subject matter of arithmetic and mathematics by Blacks and by females.

A few people have been quick to inquire how to intervene constructively to free students, parents and teachers from the constraints of their respective sex and ethnic role expectations. This last group will contribute most effectively to changing attitudes, behavior and performance, independently of sex, ethnicity or status and role in the educational system.[3]

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Footnotes

[1]A check of recent catalogs shows the following variation: Iowa State requires one year of high school algebra for admission. Students are required to have two years of high school mathematics, generally one year of algebra and one year of plane geometry, at the University of California (all nine campuses), Columbia, Hopkins, Washington, Wisconsin, Illinois, Indiana, George Washington University, Georgetown University, Pennsylvania State University, Pittsburgh, Purdue, State University of New York, Temple and Washington State. Two years of algebra and one of plane geometry are required by Michigan, Cornell, CUNY, Northwestern, Rochester, Vanderbilt and Yale. While it only requires the first three years, Yale strongly recommends the fourt, as do Harvard and the University of Pennsylvania. Princeton and M.I.T. require four years of college preparatory mathematics in high school.

[2]The calculus sequence is increasingly required for sophisticated and job relevant work in economics, political science, sociology and psychology, at the doctoral level.

[3]The constructive intervention projects with which I am most familiar are:

1. Project S.E.E.D. (Special Elementary Education for the Disadvantaged, University of California Special Opportunity Scholarship Program, 230-B Stephens Hall, Berkeley, CA 94720, 415/642-2312). This project has been conducted since 1965 in an attempt to expose disadvantaged youngsters to mathematical concepts during their elementary education. It hires math specialists from the university and private industry to teach mathematics through discovery to full-size elementary classrooms.

2. Mathematics for Girls Project, Lawrence Hall of Science, University of California, Berkeley, CA 94720, 415/642-4193. This project offers small after school and weekend classes to help elementary and junior high school girls discover that mathematics can be fun.

3. The Pre-calculus Laboratory conducted by the Computer Science Mathematics Department at Mills College, in Okland, CA 94613. This laboratory familiarizes students with the language of calculus before they get involved in the operations of it.

4. The Mathematics Anxiety Project at Wesleyan University, Middletown, CT 06547. This clinic provides diagnosis of math anxiety, standard review sessions geared especially for women and non-standard remedial work in developing spatial relations ability.

5. The work of Dornbusch, et al., at the Stanford Research Center for Research and Development in Teaching, Stanford University, Stanford, CA 94305 has generated enough media interest and public interest to generate a forthcoming three-day seminar for teachers, administrators and community representatives to consider solutions to the problems posed by sex and ethnic differences in mathematics achievement.

(The last three constructive intervention grous do not directly address the problem of sex and ethnic differences in mathematics achievement, but their work has important implications for achieving more effective and more rapid solutions.)

6. The National Manpower Institute has a major commitment to improving articulation and opening up communication between the world of education and the world of work. Willard Wirtz and the National Manpower Institute have recently produced THE BOUNDLESS RESOURCE. Chapter 8 calls for the modification of traditional role expectations based on sex, ethnicity and age.

7. The Institute for Educational Leadership has a major commitment to opening opening communication and improving articulation between the world of education and the world of political decision making (Moorfield, 1975). Their work is critical for communicating classroom experiences, needs, opportunities and problems to those who make political decisions ultimately affecting what happens in the classroom.

8. Erhard Seminars Training (est) has a major commitment to vitalizing educational systems, economic systems and political systems, through helping individuals discover their contribution to the way things are. For me it was a catalyst in what seemed like a moderately successful existence. I've since worked with "est in education," and am profoundly impressed by the ways in which the graduates use what they got from the training to free students at all levels to take responsibility for their educational experience.

Table 1: Years of High School Math by Sex:
1972 Berkeley Applicants
Admitted as Freshmen

Mathematics	Men	Women	Total
Two Years	7%	36%	21%
Three Years	36	56	46
Three and a Half Years	57	8	33
TOTAL	100%	100%	100%
(Number)	(42)	(39)	(81)

Source: University of California, Office of Admissions. $p < .001$, Chi Square = 25.066 with two degrees of freedom.

Table 2: Pursuit of Advanced High School Mathematics by Reported Social Support

	Some Social Support Reported	No Social Support Reported	Total
Took Advanced Math	13	7	20
Did Not Take Any Advanced Math	1	17	18
TOTAL	14	24	38

Source: Questionnaire Survey of upper division social science class, University of California, Spring 1973. Q = .94, Chi Square = 15.17, $p < .001$, with one degree of freedom.

Table 3: Performance in Advanced High School Mathematics by Reported Social Support

Performance	Some Social Support Reported	No Social Support Reported	Total
A's and B's	13	3	16
C's and D's	-	4	4
TOTAL	13	7	20

Source: Questionnaire Survey of upper division social science class, University of California, Berkeley, Spring 1973. $Q = 1.00$, $p < .001$, with one degree of freedom.

Table 4: Percentage Majoring in Physical Sciences, Life Sciences and Mathematics by Sex and Ethnicity

	Men	Women	Sex Difference	Total
Asian	68%	45%	23*	58%
	(615)	(538)		(1,153)
White	41%	17%	24*	31%
	(4,094)	(3,040)		(7,134)
Black	37%	17%	20*	30%
	(697)	(412)		(1,109)
TOTAL	44%	21%	23*	34%
	(5,406)	(3,990)		(9,396)
Ethnic Difference	31*	28*		28*

Source: University of California, Berkeley, Student Response Survey, Spring 1972.

*$p < .05$. Number in parenthesis is base of percentage. Read 68% of the 615 Asian men majored in the physical sciences, life sciences and biological sciences, compared with 45% of the 538 Asian women.